No. 86 May 1999

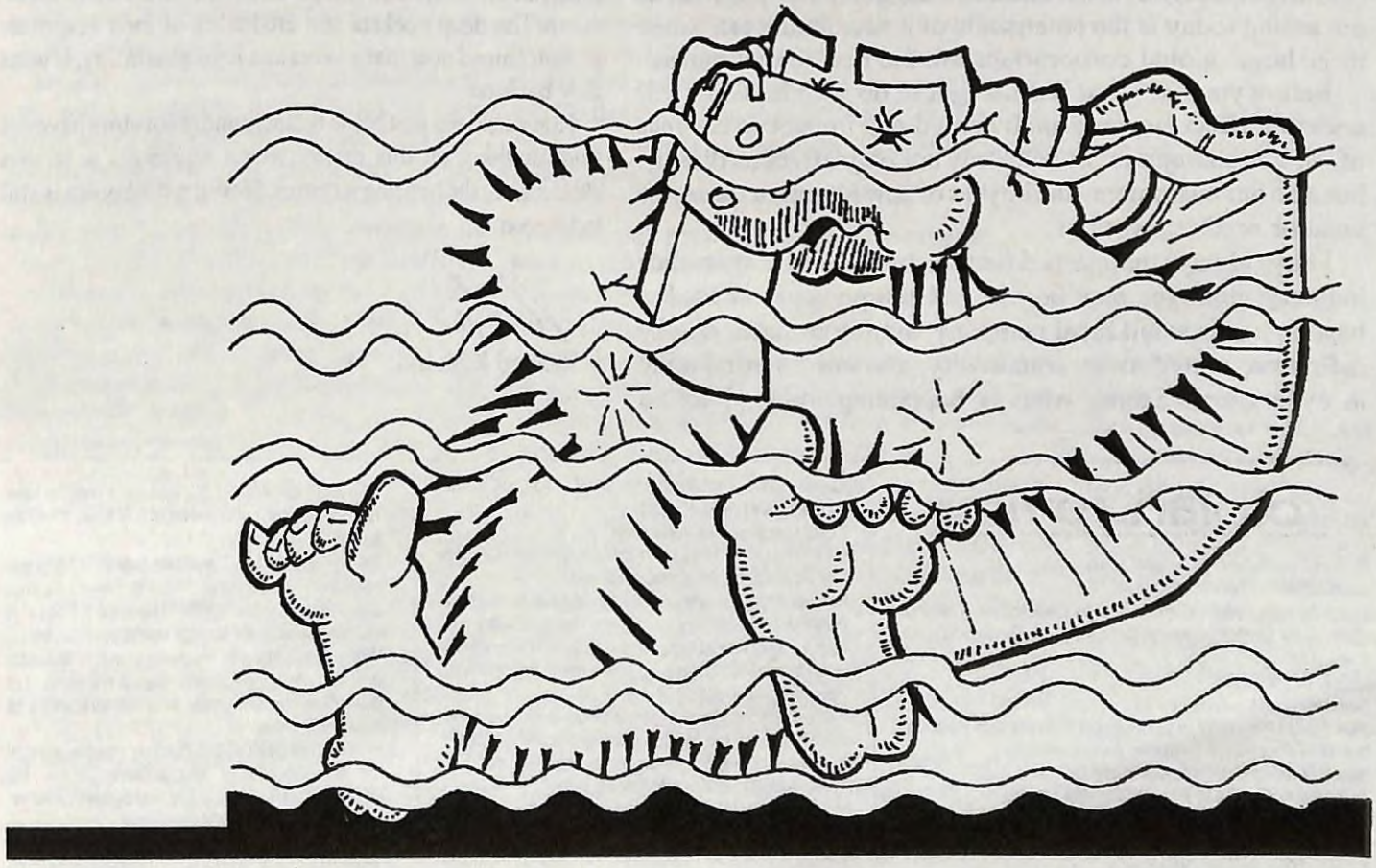
solplan review

the independent journal of energy conservation, building science & construction practice

Contents . . .

Carbon Monoxide 3
Gas Detectors: How Do They Work? 5
Detector Standards 5
Roof Ice Dams 6
How effective are gas-filled windows? 8
What is the difference between tinted and low-e glass? 8
Beam Design: Money-Saving Framing Alternative 9
Technical Research Committee News 10
Code Ventilation Requirements Being Reviewed, Envirohome About to Set A Record R-2000 Program News: Strategic Plan Approved by Builder Committee, Technical Requirements Revisions
Green Building Advisor: Advice on a disk 11
Flashings: Best Practice Guide 12
Fighting Mould 13
Performance of Sealed Insulating Glass Units with Muntin Bars 14
Energy Answers: about embodied energy 16
Letter to the Editor 17

Carbon Monoxide



From the Editor . . .

Regular readers of Solplan Review will admit that I've been known to rant from the fringes against the seemingly uncontrollable direction in which our economic system is evolving (and probably questioning the editor's state of mind). There is a belief in the world today that global economic forces are natural and unstoppable. This ignores, of course, that economies are made by humans and are not natural forces like the cycles of nature (be it weather, the changing seasons, or the forces of gravity).

The changes we see today are not the result of technology, but of changing perceptions about social order and the social contract. The ever increasing monopolization of the economy by ever larger corporations in the name of "free market" economics, is starting to have a severe impact on us all at an individual level.

As corporations grow bigger, they become less controllable and are able to blackmail the society they are meant to serve. Contrary to all the hype, large corporate entities do not create employment or innovation. The evidence is that they actually stifle innovation and eliminate jobs. In fact, what we are seeing today is the emergence of a new feudal era, where these huge global corporations are the new feudal barons.

Before you ask what has this got to do with housing, how does this affect me, read on. It has a direct impact on each one of us. The changes in the economy not only affect us directly, but also our customers - the buyers of new homes or those who want or need renovations.

I have always maintained that the residential construction industry, both for new homes and renovations, is the last bastion of the small local company, simply because it is, by definition, rooted to the community, and not a virtual entity in cyberspace. Seeing what is happening today, I am no longer sure that is the case. In many places the small service oriented local business is gone; replaced by the large box warehouse chains.

Recently I have noted how the large corporations are elbowing onto the housing industry's turf. Energy utility companies are aggressively going after business that has nothing to do with energy supply or distribution and service, but everything to do with direct competition with the small builder and renovator.

With the deregulation of the utility market, the gas utilities are moving onto this turf with a vengeance. Sewage treatment plants, subdivision servicing, home improvement (kitchen remodelling, roofing, windows, insulation), are only a few of the areas these operators are getting into. BC Gas, Enbridge (Consumers Gas), and Union Gas are only three of the high profile players in Canada that have launched an offensive. Of course, they will tell you that it is their deregulated affiliate that is undertaking this business diversification, and not the energy utility. However, it is the image of the utility that is front and centre in the consumers' mind. The deep pockets and credibility of their corporate parent, gained over many years as a regulated utility, is what they bank on.

I am surprised that home builders and renovators have not said anything on this matter which represents a serious challenge to the housing industry. How it will play out is still to be seen.

Richard Kadulski
Editor

solplan review
the independent journal of energy conservation, building science & construction practice

Editor-Publisher: Richard Kadulski
Illustrations: Terry Lyster
Contributors: Rob Dumont, Jim Gallagher, George Kerr, Joe Sartor, Henry Schultz, A. Elmahdy, Jim Stewart
ISSN: 0828-6574
Date of Issue: June 1999
SOLPLAN REVIEW is published 6 times per year by:
the drawing-room graphic services ltd.
Box 86627, North Vancouver, BC V7L 4L2
Tel: 604-689-1841 Fax: 604-689-1841
e-mail: solplan@direct.ca
Street address:
#204 - 1037 West Broadway
Vancouver, BC V6H 1E3

Canadian Publications Mail Product Sales Agreement No. 454532
Postage paid in Vancouver, BC.
COPYRIGHT 1998 by The Drawing-Room Graphic Services Ltd. All rights reserved.
Reproduction without written permission of the publisher is strictly forbidden. Transgressors who don't take heed note: those finishing carpenters you're counting on may have more thumbs than you bargained for.
A license for photocopying or other reprographic copying can be also be obtained from CANCOPY (Canadian Copyright Licensing Agency, #900 - 6 Adelaide St E, Toronto ON M5C 1H6).
SUBSCRIPTIONS: In Canada 1 year $48.15 (incl GST) (NB, NS, NF $51.75 includes HST); 2 years $86.67 (incl GST) (NB, NS, NF $93.15 includes HST). USA and other foreign payable in US $ 1 year $52.00, 2 years $94.00.

CHANGE OF ADDRESS: include a mailing label or copy all information off label for faster, accurate processing.
CONTRIBUTIONS: Unsolicited contributions and manuscripts welcome. Include self-addressed pre-stamped mailer if return requested. Publisher not responsible for loss or damage of same.
While every effort is made to provide accurate and complete information, we do not warrant or guarantee the accuracy and completeness of such information.
ADVERTISING POLICY: Publisher's discretion in the acceptance of any advertisement. No endorsement is stated or implied by the publisher.
PRINTED IN CANADA
GST Registration: R105208805
SOLPLAN is a registered trademark of the Drawing-Room Graphic Services Ltd.

Carbon Monoxide

by Richard Kadulski

Tabloid paper headlines would scream "The Invisible Killer in your home!"

About fifteen years ago, we became aware of radon as a health hazard. Then, its presence and allowable concentrations were little understood. Now we are becoming aware of the more significant presence of carbon monoxide (CO), a much more toxic substance. CO is a colourless, odourless deadly gas with no "safe" concentration. Because you can't see, taste, or smell CO, it can kill you before you know it is there.

The production of CO is entirely within our control, because of the combustion appliances we use. Properly installed and maintained appliances will reduce CO production. Trouble starts when combustion appliances are installed improperly.

Everyone is at risk for CO poisoning. However, individuals with greater oxygen requirements such as unborn babies, infants, children, senior citizens, and people with coronary or respiratory problems are at greater risk.

The danger of CO is its attraction to haemoglobin in the blood as the CO replaces the oxygen body cells need to function. Haemoglobin-carrying CO is not able to release oxygen to the tissues, which start to asphyxiate. When CO is present in the air, it quickly accumulates in the blood. Its affinity with red blood cells is up to 270 times greater than the affinity of oxygen and haemoglobin.

Breathing air containing carbon monoxide at 100 ppm (parts per million) for two hours has been shown to increase blood carboxyhemoglobin concentrations up to 16.0%, a concentration that can cause the symptoms of CO poisoning. CO is released slowly. After three to four hours of breathing fresh air only half the CO is eliminated from the blood.

Carbon monoxide in the body causes flu like symptoms, such as headaches, fatigue, nausea, dizzy spells, confusion, and irritability. Because CO reduces oxygen delivery to the brain, persons with higher levels of CO in their blood do not think clearly, and might not recognize the warning signs. As levels increase, vomiting, loss of consciousness, and eventually brain damage and death can result.

The true incidence of exposure to carbon monoxide is unknown and may be greatly underestimated, as it can be easily misdiagnosed by medical personnel as the flu or even food poisoning. Accidental CO exposure in a home can be difficult to reproduce and document. Yet exposure to CO caused by intermittent spillage from vented appliances has serious consequences.

Carbon monoxide poisoning is not directly an issue for builders. However, systems incorporated into buildings, building design and construction details can contribute to increased CO levels.

Carbon monoxide is a by-product of incomplete combustion whenever fuel does not have sufficient oxygen. In properly installed and maintained appliances, gas burns clean and produces little carbon monoxide. However, anything that disrupts the burning process or results in a shortage of oxygen can increase CO production. Wood, coal, and charcoal fires always produce carbon monoxide, as do gasoline engines. Common home appliances such as gas or oil furnaces, gas clothes dryers, gas ranges, gas water heaters or space heaters, fireplaces, charcoal grills, and wood burning stoves and tobacco produce CO. Fumes from automobiles and gas-powered lawn mowers contain CO that can enter a home through connecting walls or doorways if an engine is left running in an attached garage.

What causes carbon monoxide not to vent to the outside?

Incorrectly installed venting systems and chimneys, chimneys plugged by bird nests, tree leaves, or ice build-up, deteriorating chimneys, chimneys too short to vent correctly, appliances with no venting system, and house air flow patterns and downdrafting can all cause vent failure.

A chimney relies on the buoyancy of warm air to carry combustion gases out of the house. Unfortunately, buoyant forces are weak and can easily be overcome by kitchen and bathroom exhaust fans, clothes dryers, and air leaks in the house. Winds around the outside of the building or a chimney that is too short can create a downdraft. Although downdrafting usually disappears as the flue warms up, it can last for several hours.

The air handling blower on a furnace is much more powerful than the natural draft of the chimney, so poorly installed or leaky ductwork on the air return side can downdraft the chimney. In one documented case, an Iowa family was hospitalized

Thomas H. Greiner, Associate Professor at Iowa State University is one of North America's leading experts on carbon monoxide. He has written a number of easy to read papers on the issue. They are posted on the Iowa State University web site. These papers were valuable in preparing this story. They can be accessed at:

www.ae.iastate.edu/human_housing.htm
or
www.exnet.iastate.edu/Pages/communications/CO

Actively discourage house designs with attached garages. . . it is difficult to achieve gas tight enclosures between the house and garage.

How much should you pay for a CO sensor? Good CO detectors cost about $90. to $100. If you are offered one for much less, then it's quality is suspect.

with CO poisoning because they had removed the cover on the return side of the furnace, and that was enough to depressurize the furnace room.

CO build-up inside homes is not an issue just for new, draft free construction. Drafty, leaky older houses also are subject to CO problems.

Besides the obvious problems with leaky houses (they are hard to heat and cool, drafty, and uncomfortable) there can also be venting problems. The stack effect in a leaky house which has a large portion of its leakage located high on the house, (e.g., in the ceiling or on the second floor) creates a suction that draws replacement air into the house through the basement and lower levels. The negative pressure at the lowest level can pull air down the chimneys and vents, causing combustion gas spillage into the home.

Even installed make-up air ducts may not be adequate. Fan-powered combustion air kits which operate whenever the appliance burner is on to force air into the furnace room for combustion air and for venting are more reliable than passive combustion air pipes.

Carbon Monoxide Concentrations

CO Concentration *(ppm)*	Effects
0-2	normal ambient concentrations
9	max allowable concentration over 8 hour period (ASHRAE)
15-20	impaired performance (2-3% concentration in bloodstream)
20	typical concentration in flue gases of properly operating furnace
25	Workers Compensation Board (BC) max allowable average workplace exposure over 8 hours
50	max allowable average workplace exposure over 8 hours (USA- OSHA)
110	measured concentration in skating rink
200	maximum workplace exposure (US - NIOSH) alarm must sound within 35 minutes
800	dizziness, nausea & convulsions within 45 minutes; death within 2-3 hours
3,200	concentration inside charcoal grill
35,000	tailpipe exhaust from warm gasoline engine without catalytic converter
70,000	tailpipe exhaust from cold engine during first minute of cold weather start

Detection and remedial action are a new investigative area. Tools are still being refined, and technicians are only beginning to appreciate the subtleties involved. This was highlighted in an Iowa Study.

Indoor air quality studies in 65 Iowa homes found 29 with excessive concentrations of CO produced by the furnace or water heater. The response of professionals contacted by homeowners for help was inadequate; ten professionals claimed to have fixed the problem - but had not; six reported no CO problem and told the homeowners the problem was the CO detector when in fact there was a CO problem; three indicated there was a problem but could not find it; one said the problem was caused by freak weather, and would not likely recur - but it was a CO problem that would likely recur. Only two professionals correctly diagnosed and corrected the problem.

How can carbon monoxide poisoning be prevented?

1. Prevent carbon monoxide from being produced by proper design, installation, and maintenance of combustion appliances. In our new, more airtight houses, providing combustion air and avoiding excessive depressurization is critical.

2. Vent combustion products outdoors. Dilution with outside air is not an efficient method of removing pollutants. Providing more outside air while CO is still being produced does not solve the problem and is dangerous. Even with high volumes of dilution air, the air quality is degraded when pollutants are dumped into a space. Removing toxic materials at the source is safer and more effective.

To remove any small amount of CO that might be produced, and all other products of combustion, the heating appliances should always be vented to the outdoors. The new, direct-vent sealed combustion appliances give positive venting of all combustion products to the outdoors while increasing efficiency and lowering heating costs.

3. Install carbon monoxide detectors.

Garages and CO Concentrations

Actively discourage house designs with attached garages. Evidence is beginning to show that it is extremely difficult to achieve gas tight enclosures between the house and garage.

When a car engine is started from cold, the fuel mixture is rich (causing more CO), and the catalytic converter is ineffective. Even well-tuned engines will produce more than 80,000 ppm for the first minute or two of operation. The CO concentration will typically drop to 1,000 ppm or less after 5 to 15 minutes of operation.

A 5.5 horsepower gasoline-powered pressure washer was run in a double garage with both doors open, the window open, and a vent open. In 12 minutes CO concentrations in the garage rose to 658 parts per million (ppm).

The rate of emissions from a typical gasoline engine is so large (30,000 to 100,000 ppm) that providing sufficient ventilation is very difficult. It is NOT recommended to use equipment and tools powered by gasoline engines inside buildings.

That is why it is important not to run a vehicle inside the garage any longer than the time needed to move it out of the garage. In commercial garages and underground parking areas, large capacity exhaust fans (with CO detectors) operate continuously to lower concentrations.

Measurements in one residential garage, where a car was warmed up for only two minutes with the overhead door open, the CO concentrations in the garage rose to 500 ppm. Ten hours after the car had been backed out of the garage, there was still a measurable concentration of CO in the garage.

Residential CO detectors are not designed or approved to operate in garage conditions, so they should not be used there.

Suggestions have been made that a garage exhaust could be used to remove CO. An exhaust fan from the garage to outdoors will lower the pressure in the garage. However, the fan can also depressurize the house so vented appliances (furnaces, water heaters, and boilers) can spill their exhaust gases into the house. If a separate exhaust fan is installed in the garage, it must be checked for proper operation after installation. Even with a garage fan operating, a gasoline engine in a garage is not safe.

Detecting CO in the field

Flame colour is not an accurate measure of CO concentrations. What is normally accepted as a safe blue flame may still be producing excessive concentrations of carbon monoxide. Measurement of CO in the flue gases is the only reliable method to determine if complete combustion is occurring.

Preventive Measures.

- Install CO detectors
- Yearly service of heating appliances by a qualified service technician
- Immediate action to protect all building occupants when a detector alarms.
- Correction of problems after a carbon monoxide detector alarms.

A little known fact is that the life span of all gas sensors is limited. Smoke detectors should be replaced every 7 years or so, while CO detectors have a life span of about 4 to 5 years. The test indicator light on most detectors only tests the function of the alarm signal, and the power supply, but not the sensor itself.

Gas Detectors: How Do They Work?

Smoke detectors use a photoelectric sensor, which detects smoke by the reflection of light back to the cell, creating a current, and starting the siren. A second, more common type uses an ionizing detector. A tiny amount of radioactive material emits alpha particles into a chamber between two charged metal plates. Smoke in the chamber breaks an electric current, thus setting off the alarm.

The first commercial sensors for carbon monoxide were developed in Japan, using a metal oxide semi-conductor (also called MOS sensors). In these, the gas sensing detectors are two coiled-wire heating elements separated by an insulating material. When the right gas is present, a reaction takes place, causing free electrons to be released, thus changing the electrical conductivity, which sets off the alarm. They require power, so they are not effective during power outages, the most vulnerable time for CO generation (when combustion appliances are most likely to be used for heating). MOS sensors are not specific to CO, and can give false alarms as products such as hair spray, air "fresheners" and paint fumes can also set them off.

A further development was a technology that relies on colour chemistry to detect CO. These biometric or colorimetric sensors are more effective, but the technology was licensed exclusively to First Alert.

The latest technology, and the one that seems most stable is based on electrochemical detection. In this type any CO present reacts with oxygen in the air, affecting the current than flows through the detectors' circuit. The detector can differentiate between short term high and long term low concentrations of CO, and give warnings accordingly.

The major concern with sensor technologies is their reliability, as there can be a drift in the accuracy of the sensors. The accuracy of research grade MOS type CO sensors can change by 7% in one week, while commercial units have been tested to drift as much as 31%. Reports have shown that some detectors could fail to alarm at CO concentrations as high as 1000 ppm.

Tests of 96 detectors done by the Gas Research Institute (GRI) in the US, found that the electrochemical detectors gave the best performance overall.

Detector Standards

The standard for CO detectors has been updated three times since 1992. Unfortunately, many CO detectors sold in Canada in the past year are obsolete technology that in effect has been dumped into Canada, because the US standards have been tightened up quicker than the Canadian standard.

UL 2034 was the standard for many years, but concerns have been raised whether or not alarms meeting this standard provide acceptable performance. In the UL test, units are tested once only, from a manufacturer supplied sample (rather than a randomly selected unit). The UL standard does not require follow up testing of the samples to verify accuracy over time. GRI testing found that half the sensors tested failed to meet the UL requirements after 4 months of use.

A more robust standard is the ***IAS 6-96*** standard. The requirements are that detectors not activate at low concentrations, but must alarm at high concentrations. The low threshold is a CO concentration that would result in a 5% carboxyhemoglobin concentration in human blood, or 100 ppm for 35 minutes, 65 ppm for 65 minutes, 50 ppm for 60 minutes separated by 6 hours clean air, or 30 ppm for 30 days.

In Canada, the Canadian Standards Association is about to release its new standard, which will be known as ***CGA 6.19-98***. This standard, which mirrors the IAS requirements, should be in effect by October of this year. When selecting a CO detector, look for the IAS or CGA standard label.

Roof Ice Dams

It's Not Really a Roofing Problem!

Nothing highlights construction shortcomings like severe winter storms. Too often, possible problems are neglected during the construction season when winter and its bad weather seem far removed..

The winter of 1999 produced many ice dams on shingle roofs in central and eastern Canada. The resulting leaks caused widespread damage to ceilings, walls and interior furnishings of many homes.

by Joe Sartor

Why Ice Dams Form

Ice dams are caused when heat from the attic melts the accumulated snow on the shingles above the outside wall, while the snow on the eaves overhang and in the eaves trough does not melt because it is surrounded by cold outside air. The melting water then freezes as it runs down over the cold overhang, and forms a dam that prevents the water from the melting snow getting down and away in the eaves trough.

As the level of the dammed melt water rises, water starts to run up and under the shingle tabs. The water then enters the vertical joints between the shingles, and spills down onto the roof sheathing, where it spreads out, finding joints or holes in the sheathing, and dripping down onto the insulation over the ceiling near the outside wall. If the water does not go any farther, nobody notices, and it is not a problem. However, when enough water accumulates, it spills over or soaks the insulation, and wets the ceiling drywall or plaster below- becoming a built-in leak problem.

The Usual Remedy

For new construction, a common procedure for preventing leaks of this kind is to apply a width of waterproof membrane, such as peel—and-stick membrane to the sheathing under the shingles at the eaves so when the dammed melt water leaks through the shingles, it cannot wet the sheathing. Some building codes may require this membrane over the eaves, or a shingled layer of asphalt-impregnated felt paper covering the whole roof under the shingles.

A popular remedy for existing houses is to install heating cables in a zigzag pattern on the shingles over the overhang to melt that snow so that no ice dam can form. Heating cables have their drawbacks. People forget to turn them on, so ice dams can still form, or they forget to turn them off and risk overheating and damaging the shingles.

What seems to have been forgotten by everyone involved in this kind of remedial work is that installing a membrane, felt layer, or heating cables only treats the symptom and not the cause of ice damming. Left unresolved, ice damming can damage the roofing, as freeze/thaw cycles acting on the melt water under the shingles can lift the nails and bend or crack the shingles. The wood joists, rafters, and sheathing can also rot over the years if wetted by the leaks.

The Real Remedy

The cause of ice damming has nothing to do with the roof or the shingles. It has everything to do with heat loss due to low insulation levels at the ceiling edge, proper attic ventilation at this point and warm air leakage from the house below. If no heat escapes from the ceiling edge, and there is enough attic ventilation on the underside of the sheathing, the shingles will not heat up enough to melt the snow near the eaves. There will be no melt water and no ice dam, and thus no leaking.

To correct or prevent both the ice dams and the leaks, it is not the roofing that needs remedial work, but the ceiling edge insulation, air leakage and eaves ventilation. Sometimes air leakage from inside at the wall is the main problem and needs to be corrected.

Increasing the amount of attic ventilation to prevent the escaping heat from melting the snow on the roof seldom works. Increased attic ventilation does not dissipate the heat escaping from the ceiling below to stop the snow on the roof from melting at that point.

What is really needed is full depth ceiling insulation at the roof edge, full ventilation at every rafter space between the top of the insulation and the roof sheathing, and eliminating interior air leakage especially near the outside wall. If there is no heat under the sheathing, there will be no melting and damming on the roof and no leaking through the roof into the ceiling below.

Examining The Problem

A close look at a typical wall/roof/ceiling detail shows why leaks due to ice damss happen so often.

Usually, the rafters are low to the top of the outside bearing wall for reasons of economy or aesthetics, bringing the roof sheathing very close to the ceiling edge below. This means a restriction in the insulation that can be fitted between the ceiling and the sloping roof, resulting in excessive heat loss into the roof at that point. In addition, there is seldom a full ventilation space between the rafters above the insulation, so a thermal bridge is created that allows the heat loss to warm the sheathing and shingles, and melt the snow which then freezes to cause the damming and leaking. Usually there is a lot of air leakage at the outside wall, adding to the heat concentrated under the roof at that point.

To conform to the insulation requirements of most current building codes, the space under the roof sheathing should be about 12" thick at the outside wall. (10" for batt insulation and 2" for ventilation; at the very minimum, the insulation over the outside wall should be no less than the insulation in the wall.) Very few roofs meet this requirement. Some older homes only have about 4 - 5" for both insulation and ventilation above the ceiling. And of course, the older homes have more air leakage at the outside walls directly below this vulnerable location, especially if they are solid brick with lath and plaster on strapping.

Preventing Ice Dams on New Construction

First, air leakage from the ceiling, and especially from the corner at the outside wall, must be eliminated to keep that area cool. If roof trusses are used, it is simple (but slightly more expensive) to raise the heel by cantilevering the bottom horizontal truss member or raise the heel of the truss to fit the required insulation and ventilation space. If framing is used instead of trusses extra work will be required to raise the rafters to provide this space.

Naturally, raising the roof sheathing will change the outside appearance of the house as it raises the eaves and exposes more outside wall at the top over the windows. Some builders resist doing this as it may alter the aesthetics besides increasing costs. However, not doing it usually results in ice damming in most Canadian climates.

Correcting Ice Damming on Existing Houses

Controlling the air leakage, providing enough insulation and ventilation in a thicker, more airtight roof structure will prevent ice damming in a new house. But what about an existing house experiencing this problem? How do we remedy it? In a restricted space, we need to provide adequate insulation, ventilation, and eliminate air leakage from the inside.

Make sure every rafter space is vented across its full width, using properly-sized vent baffles above the insulation. Where trusses have not been used, this is difficult because the ceiling joists are usually nailed beside the rafters, so the vent space is narrower and not uniform in width. Regardless the difficulties, it must still be done properly to be successful.

Remove the insulation and any wood members which might interfere with new insulation and ventilation. From the ceiling edge, fit properly-sized vent baffles, making sure that there is a minimum 1½" depth for ventilation across the full width from rafter joist to rafter joist in every rafter space. Then apply low-expansion spray-in-place polyurethane foam insulation. The foam insulation must completely fill the tapered space under the baffle and over the ceiling between the ceiling joists/rafters, from the outside of the structural wall inward far enough to allow the full depth of batt insulation to continue. When installed this way, the foam insulation provides high-quality insulation, (more than R-6 per inch) filling in all the nooks and crannies effectively reducing thermal bridging in this tight space. Foam insulation also seals off, any air leakage in that area. This is especially important in older, solid brick-&-block houses, where there is massive warm air leakage upwards from the vertical strapping space between the plaster and the masonry wall.

By doing the corrective work, all conditions which might heat the roof sheathing and produce ice dams (warm air leakage, inadequate insulation, and lack of full ventilation space under the sheathing) have been eliminated.

Ice damming, the resulting leaks, and possible damage to the roof itself are eliminated by simply bringing the ceiling insulation, roof ventilation, and air leakage up to current code standards, both in existing houses and in new construction. Just fixing the roof will not do it, because it is really not a roofing problem.

Joe Sartor is a building science consultant in Toronto specializing in building envelope leakage and condensation problems. He has 35 years experience as a construction superintendent, and is a member and former director of the Ontario Building Envelope Council.

You asked us:

How effective are gas-filled windows?

We are told we should use gas filled, low-e windows. However, our window supplier is not keen on it. He tells us that the industry cannot prove how much argon is in the window, so we may be spending extra money on something we are not getting. Is that true?

Heavy gases, such as argon (and occasionally krypton) are used in sealed insulating glass (IG) window units because these reduce heat loss due to conduction and convection. These gases are used in conjunction with low-e coated glass and insulating spacers to increase a window's overall thermal performance.

To maintain this increased thermal performance, the argon must remain in sufficient quantity over the service life of the unit. However, determining the concentration of heavy gas fills in an IG window is a challenge for the industry.

At this time, no simple procedure can be used on-site to find out the type of glazing and gas fill that is present in a given window. However, test procedures for the durability of sealed insulated glazing have been around for many years. These include measuring dew point temperatures before and after simulated ageing, and a fogging test that determines the degradation of the organic compounds used in the sealing. Measuring the dew point temperatures before and after each test provides an indication of the quality of the sealant and the capacity of the desiccant to absorb moisture within the window unit.

The normal concentration of argon in the atmosphere is about 1%, so the higher gas concentration inside the unit creates a gas pressure difference that, in a failure, would drive the argon from the window cavity. It is the quality of the seal that determines how much leakage there will be.

The gas filling process used most often is to puncture the spacer bar in two locations, one near top and one near the bottom of the IG unit. One lance supplies the gas, while the other is used to draw out the original air. A gas detector at the pump shuts off the pump when a certain amount of gas is pumped into the space. The lance is then removed and a plug and seal inserted to cover the puncture. When done correctly, the gas should fill about 95 to 98% of the cavity. Recent laboratory tests that tried to establish testing procedures for gas concentrations showed that average argon concentrations actually varied from 79% to 93% - but at these concentrations, the gas fill is still effective.

Most window units retained their argon gas, with a loss of about 1% argon gas per year through the edge seal, except where the seal failed totally, which would have led to replacing the unit anyhow. Dual sealed IG window units resist gas diffusion better than single sealed units. (The accelerated ageing test represents about 5 years of actual service life.)

It is interesting to note that window units with a silicone foam spacer had higher argon concentrations and higher gas retention than other spacers including corrugated metal insulating spacers and conventional metal spacers. In part, this might be explained by the self sealing nature of a foam spacer compared with metal.

R-2000

For information on the R-2000 Program, contact your local program office, or call 1-800-387-2000

What is the difference between tinted and low-e glass?

Tinted or low-e glass.... which is better at keeping heat out while letting light in?

Developments in the window industry mean that while superficially glass used in new buildings may appear identical to glass found in older buildings, the glass has completely different properties. You have to be clear what your expectations for the glass are. Glass available today, even for the residential market, can be selected based on the section of the light spectrum to be allowed come in or to be kept out.

The Ultra violet (UV) portion of the light spectrum is one we know because of its problems: it is the portion that bleaches colours out of furnishings and inside finishes. To keep the UV rays out, glass with plastic films, such as Heat Mirror or laminated glass is needed. (You cannot get sunburned inside a car because car windows are laminated glass).

The infra red portion of the spectrum supplies the heat. Various types of glass allow varying amounts of the infra red spectrum to enter.

The visible light section is what windows are all about - letting light into the building. Again, properties of differing glass allow more or less light in.

The accompanying table was developed with a simple light analyser used by one manufacturer to show off the properties of their glass units compared to their competition. Although it is not a rigorous scientific review of varying glass types, it does show the relative differences of glass. From this, you can see that tinted glass not only keeps heat out, it keeps light out too.. This makes it important to choose the correct low-e coating.

Window performance factors

Glass combination	UV transmission %	Visible light transmission %	Infrared transmission %
clear/clear	76	82	63
hardcoat low-e/clear	57	76	59
low-e squared /clear	23	73	15
clear laminated /clear	3	79	54
Azurlite/clear	55	58	5
Evergreen /clear	12	52	6
Grey reflective/clear	9	23	28
Heat Mirror TC88	0	66	26
Heat Mirror TC 66	0	55	14
Heat Mirror S75	0	63	8

Beam Design: Money-Saving Framing Alternative

There is a tendency to think of alternatives to code requirements as more costly and time-consuming. However, standard framing practices often use more materials and cost more than they need to. This was brought out by Henry Schultz, a Winnipeg builder, who has created an alternative to standard framing that is more functional and that saves money too.

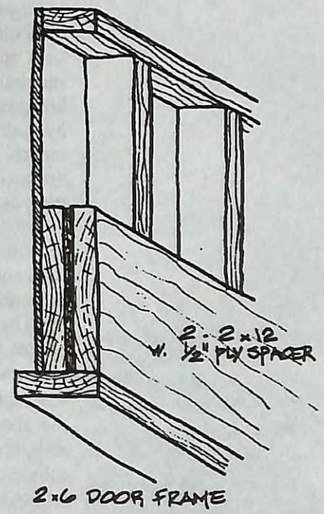
The building code requirement for a lintel over a 16-foot opening (i.e., a garage door) is for 3-2 x 12's. Henry considered that to be a waste of materials. As a result he designed a plywood box beam engineered for 16 foot openings.

Henry's beam uses 2 - 18' 2 x 12's and a half sheet ½" plywood. He estimates that the total cost for the beam, including construction time, is $89.50. This compares with a material and labour cost of $125.00 for the traditional 3 ply built up beam called for in the code. The adequacy of this detail has been confirmed by Walter Wolfe, a professional engineer in Winnipeg.

The beam lines up flush with 2 x 4 garage wall framing, and makes a better surface for the installation of overhead doors.

If only 5,000 garages were to use this kind of detail, it would represent a savings in lumber of around 200,000 board feet, or enough lumber for at least one house.

Henry's idea illustrates the point that there are many alternatives to meeting code requirements.



Solplan Review Back Issues

A limited number of back issues are available, at a special price of $5.00 each (plus 7% GST).

Bundle special: a random selection of back issues (minimum 22 copies) are available for only $55.00 (plus 7% GST).

Solplan Review
Box 86627,
North Vancouver, B.C. V7L 4L2
e-mail: solplan@direct.ca

Did you know that in the USA, low-e glass is now installed in nearly two thirds of new high end homes, and in more than one third of all starter homes?

We do not have the same breakdown for Canada, but the data such as it exists suggests that about 34% of all residential windows sold have low-e coatings.

With our much harsher climates, I wonder why the penetration is not greater?

Technical Research Committee News

Canadian Home Builders' Association

Code Ventilation Requirements Being Reviewed

A Task Force on Ventilation Standards has been set up by the Canadian Codes Centre at the National Research Council to review the present prescriptive standards in the National Building Code.

As we have reported in past issues of Solplan Review, many concerns have been raised about the present language of the code. Although the code clearly identifies that the intent of ventilation standards is to meet the CSA F326 Residential Mechanical Ventilation Standard, prescriptive requirements were added to make interpreting the code easier for home construction. Builders building R-2000 homes already meet these requirements. However, those following the code's more basic prescriptive requirements are having more difficulty complying with these regulations.

A study to see how builders are meeting the requirements has found that many problems are being encountered in the field. This is compounded by conflicts with interpretation of gas code requirements. There have been cases where ventilation systems operating to code may have contributed to back drafting of gas appliances.

Issues that will be looked at include protocols for testing depressurization in houses, problems with equipment installations, installer qualifications and required training, and outdoor air hook up. The outcome could suggest simplified means of compliance, and even review the performance requirements of the code standard. The intent is to look at both short term and long term solutions - the short term solution would be how best to address current compliance problems; the long term solution would be to consider improvements to the requirements.

Envirohome About to Set A Record

The Envirohome is a marketing initiative that builds on the technical depth of the R-2000 Program. Designated Envirohomes are R-2000 homes that go beyond the minimum R-2000 technical requirements, and include all environmental options in the pick lists. The extra marketing given to the projects offers builders the opportunity to showcase their products and set themselves off from the masses.

Interest in Envirohome is growing, so this year it appears that a record number of showcase homes will be opened in all parts of Canada. The first opened in Regina in time for the CHBA national convention. Others now open, or soon to open include homes in Cobourg, Port Hope, Toronto, and London in Ontario, Lethbridge, Alberta, Nanaimo, BC, Bathurst, New Brunswick, and Halifax, Nova Scotia.

Anyone who would like more information on this initiative should contact Gary Sharp at the CHBA national office.

R-2000 Program News

Strategic Plan Approved by Builder Committee

The CHBA R-2000 Builder Committee has approved a new business and marketing plan for the R-2000 program. It is hoped that a revitalized program will be launched by this Fall. While the marketing plan will aim at increasing public awareness of the R-2000 brand, it will also focus on climate change issues. The housing industry has a significant role to play in reducing Canada's greenhouse gas emissions. Because they are much more energy efficient, homes built to R-2000 standards make a significant contribution to this goal. However, for the industry as a whole to have an impact, a larger proportion of new homes should be built to R-2000 levels.

Technical Requirements Revisions

A review of the R-2000 Technical Requirements has been completed, and as we went to press, the revised standards were to be approved. Mostly, the changes are minor tweaking of the standards to clarify the requirements. In the nextissue of Solplan Review we will provide a review of the significant changes.

Energuide for Houses

The Energuide labelling program was only launched late last year, but has already rated over 5,000 homes in various parts of the country. The label provides a single number rating, based on a site audit and calculation.

The information provides home owners with suggested options for upgrading their homes. Although the focus is primarily on energy use, the information also deals with comfort related issues. Some utilities, renovators and heating contractors are using the program as a marketing tool and a means of providing a value-added service.

The Technical Research Committee (TRC) is the industry's forum for the exchange of information on research and development in the housing sector.

Canadian Home Builders' Association, Suite 500, 150 Laurier Ave. West, Ottawa, Ont. K1P 5J4
Tel: (613) 230-3060
Fax: (613) 232-8214
e-mail: chba@chba.ca

Green Building Advisor

Advice on a disk

How do you decide what a "green" building is? Are R-2000 houses really "green?" Are C-2000 buildings "green?" Many building performance rating systems around the world were discussed at the Green Building Challenge conference in Vancouver last year. A prototype assessment tool was also shown at the conference.

Green building design is a complex process involving the integration of broad principles and fine details. As the number of variables increases, the task becomes more complex. It will likely be some time (if ever) before an acceptable "green building" definition emerges. Meanwhile, as awareness of environmental issues, resource scarcity, indoor air quality, and global issues increases, there is a steady groundswell of professionals and owners wanting to take correct action when planning their projects. So what is the "green" approach to a project?

A new software tool, the ***Green Building Advisor***™ (GBA), may help users identify strategies for reducing the environmental impact of a building project, while ensuring healthy and productive indoor spaces.

The Green Building Advisor provides an easy way of learning about green design and the cutting-edge techniques and technologies to accomplish it. GBA is designed for anyone who wants to examine environmental opportunities for specific building projects or to learn about the many elements of green building design. The software will also be a useful tool for anyone planning a new structure or a renovation who wants to ensure that their design team is aware of green building opportunities and benefits.

Based on information the user enters about a building project, the program selects and recommends appropriate design strategies organized into five broad areas of environmental impact: site impacts, energy use, water, resources/materials, and indoor environment. Details on each strategy include an explanation of the strategy, a discussion of the environmental benefits and possible drawbacks, information on relative cost and applicable building phases, useful references for additional information, and case studies where the strategy has been used. The information provided is qualitative only, so that detailed analyses still have to be done for a given project. However, it gives a quick assessment of some major concerns that need to be addressed.

Included in the package are 290 annotated bibliographic references, listings of 1,300 green building product suppliers, and more than 700 green building design strategies. Case study files include a wealth of information, including photos, on eighteen leading-edge green building projects throughout the United States (but only one in Canada).

A significant shortcoming of the software is that it is so US focused. While the principles are universal, applicable anywhere, products, resources and location files may not always be applicable for Canadian locations or elsewhere.

The GBA software was developed for a US audience, through a collaborative effort of three organizations and a large team of green building professionals. These include the Center for Renewable Energy and Sustainable Technology (CREST), a not-for-profit organization based in Washington, DC, that creates interactive software tools on energy and sustainable development; Environmental Building News, and Design Harmony, a North Carolina environmental architecture firm. The project was funded in part by the US Department of Energy, the US Environmental Protection Agency, and the US Army Construction Engineering Research Laboratories.

For single family builders and designers familiar with R-2000 and CMHC's Healthy Housing information, this package will be of limited use. However, for those also involved with multi-family and commercial projects this will be a useful resource, especially for early stages in a project. Because of its general approach, it can also be used by clients.

Green Building Advisor is an interactive CD-ROM for Windows and Macintosh. It costs US$179 (plus shipping and handling) and may be obtained by calling CREST at 888-442-7378 or through the CREST Web site: http://wwwcrest.org. or e-mail (gba@crest.org).

Flashings
Best Practice Guide

Flashings are an important line of defence in a building's moisture protection assemblies. They intercept and direct the flow of water to designed drainage paths, and prevent water from penetrating the building.

When designing or installing flashings, consider the direction of water flow. Surface tension allows water to move upward and sideways along the underside of a horizontal surface as well as downward. In tight spaces, a small gap at least ⅜" (9 mm) wide will break the surface tension, allowing the water to drain away. A drip edge also breaks that surface tension and allows water to drop by gravity.

Capillary action can draw water into small openings (less than 5 mm). Design of joints and upturns needs to allow for this.

Flashing Performance Requirements

When selecting flashing materials, consider the following performance requirements:

Water Barrier

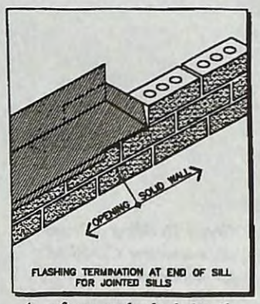
The flashing must shed water without allowing leakage. Surfaces should slope in the desired direction of flow (minimum 10% slope). Points of discharge should project out beyond materials below. On sloped surfaces they should be lapped in shingle fashion so that the natural direction of the water is over and onto the next water-shedding surface.

Movement Capability

The flashing must accommodate differential thermal and structural movements.

Terminations

Terminations should be sufficiently rigid at points of discharge to project water away from materials below.



An often overlooked detail: the termination of a flashing at a wall or change in level.

Durability

The flashing must be tough enough to resist physical damage during construction, and during normal wear, which may be related to the environment and building-maintenance activities. Other factors to consider include deterioration from corrosion, metal incompatibility and galvanic action, exposure to ultraviolet (UV) light, extreme (hot and cold) temperatures, freezing water, and fatigue due to movements.

Overall, the service life of flashings must be equal to or more than that of the wall or roof systems.

Compatibility

Flashings and their primers and sealants must all be chemically compatible with adjacent materials. Contact between dissimilar metals can lead to galvanic corrosion when the metals are moist as the water acts as the electrolyte.

Alkaline concrete and mortar aggressively attack materials such as aluminum and copper.

Buildability

A flashing detail that is easy to build will greatly increase the likelihood that the flashing will be built properly. Points to consider include:

- Can the flashing installation be sequenced so that it is separate from other construction activities, or can it be easily incorporated into other work? For example, co-ordination may be required between roofing and masonry activities at wall-roof junctions.
- If the installation of the flashings is to be incorporated into other work, do the workers have the required technology and skills?
- Can the flashing accommodate normal stresses?
- Is it possible to mould or modify the material to accommodate unusual conditions, or is it possible to repair damage?

Maintenance

Materials or joint sealants with limited service lives should be avoided if the flashings are not accessible for replacement.

Metal flashings anchored by being built into concrete or masonry cannot be removed to allow for inspection or repair of the materials underneath. The flashings and sealants should be inspected annually, particularly in areas with the greatest exposure to water and sunlight.

The latest in the CMHC series of Best Practice Guides is ***Flashings***. This document provides designers, builders, building owners and building managers with a general understanding of the principles and best practices in the design and construction of flashings. The Best Practice includes a complete master specification in generic text format and many example details – all of which are included on a CD-ROM disc that comes with the document package. (The drawings are AutoCAD DWG and DXF files). $89.95

Canada Mortgage and Housing Corporation.
1-800-668-2642
Outside Canada phone 613 748-2003

Fighting Mould

Many urban residents escape the city to a country cottage for rest, relaxation, and the healthy country air. Yet for how many is the pungent mouldy smell at the beginning of the season an annual ritual? Whether at the cottage or in your home, moulds are a sign of excess moisture, which can be the result of inadequate insulation or ventilation.

Moulds are micro-organisms that feed on a variety of substances especially, but not exclusively, dust and dirt. Moulds have a direct impact on health. They can cause allergies and respiratory disease. The toxins that moulds produce can wear down the immune system - leaving people, especially children, vulnerable to many illnesses. If moulds are discovered, they should be destroyed quickly.

Moulds are not always easy to recognize, because they often look like a simple stain, smudge or discoloration. If one patch of mould is present, make a thorough search of the house as there may be others. To identify a mould, dab suspected marks with a drop of chlorine bleach. If the colour changes or disappears, the stain is likely organic and probably a mould. Moulds can grow on or in anything, but only in damp conditions, and are most commonly found in basements, kitchens or bathrooms.

Preventing mould growth

The best way to prevent mould growth is to keep a home as clean and dry as possible. This means correcting sources of moisture. Renovators should look for damp and mouldy areas before starting a project. Obvious thermal bridges and uninsulated areas should be corrected. If the temperature is allowed to fall below the dew point, as can happen in a poorly insulated, unheated building, then moisture will condense on the cool surfaces.

Chlorine bleach is the only product that kills moulds on contact. After mould patches have been killed off, carefully wash down the entire area with a bleach cleanser, rinse thoroughly, and dry quickly.

Whole-house mould

Throw out anything that has been wet or damp for days or weeks. Discard mouldy items used daily, such as mattresses, bedding, upholstery or plush toys, because these are impossible to clean. Each time they are used they just re inject moulds into the air.

Scrap mouldy carpets, which can trap more mould than any other material. Carpets can be dry-cleaned but at a high cost. If carpets smell only slightly musty, vacuum them, brush in a large amount of baking soda and leave for three or four days, then vacuum thoroughly again. Alternatively, steam clean them lightly and dry rapidly. Do not soak!

Mouldy books and papers are difficult to treat. If they are valuable, dust between each page with baking soda, put the materials in a plastic bag and place them in the sun for several hours.

All non-mouldy surfaces - walls, ceilings and floors - can be scrubbed with a bleach cleanser, rinsed and dried thoroughly and quickly.

All non-electrical equipment, such as duct work, can be vacuumed, wet-wiped, rinsed and dried. Vaccuum light fixtures, wiring boxes and appliances with a plastic wand after turning off breakers or removing fuses.

Vigorous vacuuming may increase exposure to mould spores, which can pass through ordinary vacuum filters and remain suspended in the air for hours or days. Central vacuums that vent outside, or vacuums fitted with HEPA filters, will reduce this exposure.

When working on mould patches, always protect yourself with gloves and an appropriate face mask. For small localized areas, an inexpensive disposable face mask may be adequate; for larger areas use a full face respirator with an approved, disposable HEPA filter.

Always ventilate your work area when using bleach - open outside doors and windows. If necessary, use a fan to increase the air flow.

*Extracted from Clean-up **Procedures for Mould in Houses** CMHC Publication No. NHA 6733 ($2)*

Bleach Cleanser

Mix one part chlorine bleach, four parts water, and a few drops of non-ammonia dishwashing detergent to cut surface grease and grime. Never mix an ammonia detergent with bleach - it releases dangerous chlorine gas.

NRC·CNRC

Performance of Sealed Insulating Glass Units with Muntin Bars

by A.H. Elmahdy

Recent IRC research has shown that the presence of muntin bars can reduce the R-value and condensation resistance of sealed insulating glass units (IGU). It was also found that certain muntin bars release volatile organic materials upon exposure to ultraviolet radiation, causing fogging of the glass.

Six IGUs were tested for R-value, interior glass surface temperature and temperature index. (The temperature index relates the interior surface temperature of a window to the exterior temperature and the window's thermal characteristics, and is a measure of condensation resistance.) Test units were 1x1 m, double-glazed, either air or argon-filled, with either aluminum or vinyl muntin bars, and a low-emissivity (low-e) coating on one surface of the glass. For comparison, two units with no bars were also tested.

The R-values of the units with muntin bars were 2.3% to 7.3% lower than those of the units without. The reduction in R-value is due to thermal bridging next to the muntin bar. This can be expected because the muntin bars, made of aluminum (anodized or painted), vinyl, or silicone foam, usually have a higher thermal conductance than the air in the cavity.

Where there are large temperature gradients across the air cavity of IGUs, units with muntin bars have lower glass surface temperatures than units without, especially in the areas next to the muntin bar. When air circulates in the space between the glass of an IGU due to natural convection, a localized high air velocity exists between the glass and the surface of the muntin bar. The result is a higher rate of heat transfer through the glass, and hence, a lower glass surface temperature. This occurs mainly near the muntin bars. A lower glass temperature may lower the window's resistance to condensation so that condensation is more likely to form, especially near the muntin bars.

Units with muntin bars had a much lower glass surface temperature and temperature index at the location of the bars than did units without bars. Units with vinyl muntin bars had a lower glass surface temperature than units with aluminum bars. This is not because vinyl has a higher thermal conductivity than aluminum; but it shows that the environment around vinyl muntin bars is more conducive to condensation than that around aluminum bars. It may be because the gap between the muntin bars and the glass surface is not the same in each case, or sometimes the bars may actually have touched the glass surface.

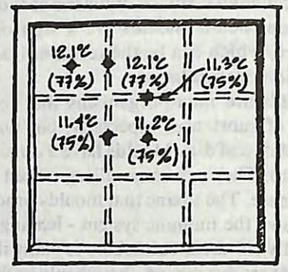


Figure 1: An air-filled IGU with no muntin bars (the control unit). This shows representative room-side surface temperatures which can range from 11.2°C to 12.1°C. The percentages are temperature indexes, which measure resistance to condensation (the higher the percentage, the better).

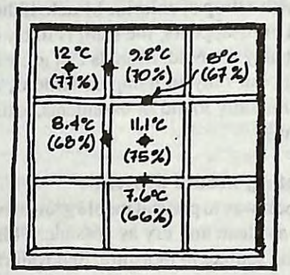


Figure 2. An air-filled IGU with vinyl muntin bars. Cold spots - as low as 7.6°C - over the muntin bars are caused by thermal bridging.

Fogging Tests

Ultraviolet ("fogging") tests (according to the CAN/CGSB 12.8) were done on 54 IGUs, representing many variations in design and configuration: spacer bars made of metal, corrugated metal strip, and silicone foam, and muntin bars made of aluminum, vinyl and silicone foam. The fogging test identifies the potential for failure due to degradation of the organic materials and subsequent release of volatile compounds, which form chemical deposits in the IGUs.

Dr. A.H. Elmahdy is a senior research officer in the Building Envelope and Structure Program of the National Research Council's Institute for Research in Construction. Further details of this research will appear in IRC's Construction Technology Update series, available on subscription. (See the insert in this edition of Solplan Review.)

For each of 18 IGU types, three units were exposed for seven days to ultraviolet radiation emitted from a standard sun lamp. Two units of each set contained a low-e coating on one glass pane, while the third (control) unit had clear glass on both panes. The units were mounted in a box with the sun lamp and a cold plate. When the ultraviolet radiation is applied, volatile materials evaporate. These materials then condense under the cold plate. During the test, the cold plate was placed on the surface of the low-e pane (for one unit) and on the clear glass pane of the second coated glass unit. This was done to examine the influence of the low-e coating on the detection of the volatile deposits.

After exposure, the units were examined individually in a viewing box for the presence of chemical deposits. In practice, an IGU fails the standard fogging test when the operator, viewing straight on, observes any oily deposits or traces of fogging on the surface of the glass. When viewed straight on, most IGUs pass the test. In the tests conducted at the IRC, viewing was done both straight on and at an off-angle. When viewed straight on, most of the tested units showed no sign of deposits. However, viewed at an off-angle, many units showed traces of deposits because the reflection/refraction of light through the thin film deposits made them more visible.

Where the cold plate was placed on the low-e glass pane, volatile materials were observed under the plate (indicating failure). The control units (no coating) showed no fogging. The low-e coating evidently enhances the visibility of the chemical deposits. This can be attributed to the relatively rough surface of coatings compared to the surface of float glass. If the deposits are smaller than the valleys in the low-e coating, the deposits tend to settle in these valleys and become more visible.

Material Degradation with UV Exposure

The degradation of organic compounds under ultraviolet (UV) exposure has been a known phenomenon for years. IGUs may fail the test for fogging deposits whether or not there are muntin bars in the cavity. This is because organic materials are used in most common sealants or other components in the IGU. Adding muntin bars introduces a source of volatile material that may fail. It is unlikely that there is any in-plant problem with the paints baked on or anodized on the aluminum bars, but there could be if touch-up paint is used on flaws or chips in the anodized coat.

Muntin bars made of silicone foam are an exception: no problems were detected with them. With metal bars, preparation includes cutting, usually involving the use of lubricants and coolants. The result can be the introduction of oil into the IGU. This happens often, especially when the muntin bars are not properly washed after cutting. Oil in the IGU also could be the result of handling the glass sheets and other components with contaminated gloves or fingers.

More research is needed to learn why IGUs without muntin bars can also fail the fogging test. It is possible that the sealants, edge seals, desiccants, or some combination thereof, are responsible for the failure.

Implications

Of the two issues addressed here, fogging may be the most serious. Homeowners would notice fogging and might think it is condensation between the panes caused by a seal failure. Until further research is done, architects, builders and renovators should be cautious when using IGUs with internal muntin bars, as they introduce an additional source of volatile material that can cause aesthetic failure.

energy efficient, sustainable, and healthy buildings
design & consulting services
R-2000 File Management
HOT-2000 Analysis

Richard Kadulski Architect

#204 - 1037 West Broadway
Vancouver, B.C. V6H 1E3
Tel: (604) 689-1841
Fax: (604) 689-1841

e-mail: kadulski@direct.ca

Energy Answers

Rob Dumont

What does "embodied energy" mean?

Embodied energy is how much energy is required to produce a material, to deliver it and install it on site.

Why is embodied energy of interest?

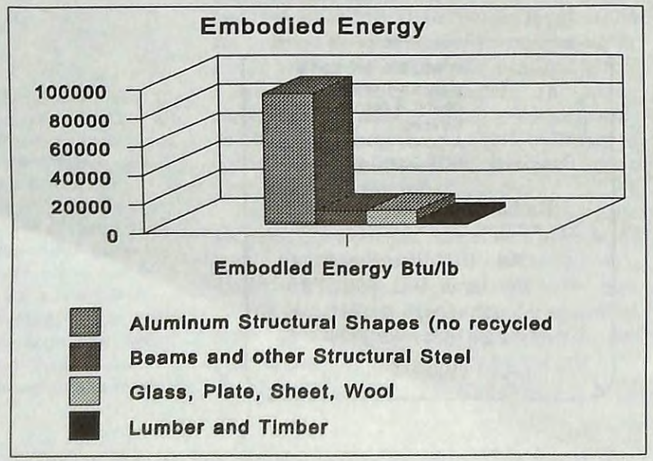
Embodied energy is important because it is a part, sometimes a major part, of the total energy use of a building over its life. To take an extreme example, a building that was completely made out of aluminum would have much more embodied energy than a similar building made completely out of wood. Aluminum is a very energy intensive material–one wit described aluminum as "solidified electricity." In general, using materials that have low embodied energy is desirable.

What are some numbers for the embodied energy of construction materials?

Here are some values for common building materials:

Embodied Energy	
Material	*Btu/lb*
Aluminum Structural Shapes (no recycled content)	90,900
Beams & other Structural Steel	9,389
Glass, Plate, Sheet, Wool	9,724
Lumber and Timber	3,347

References: Optimize, Sheltair Scientific, for CMHC, 1991; Stein and Serber, 1979



The above table compares four materials on a Btu/lb basis: lumber definitely has the lowest embodied energy, and aluminum has the highest when the four materials are compared in this manner. However, the above comparison has a definite weakness in that a pound of aluminum has a different strength than a pound of softwood lumber or a pound of steel. The fairest way to compare these materials for embodied energy is to use an actual building, and to compare the total embodied energy of the same building when constructed using different types of materials.

Is the embodied energy of a material a fixed physical property, like its density or heat storage capacity?

Unfortunately not. A lot depends on how efficiently the raw material was made into a finished product, and a lot also depends on how much energy is needed for transporting the finished material to the building site. Thus a wood frame building constructed next to a sawmill in the middle of a tree farm would have a lot less embodied energy than the same building transported to the middle of the Sahara desert. Another factor is the amount of recycled content in the product. Recycled aluminum and steel generally have lower embodied energy than virgin aluminum or virgin steel.

Is embodied energy the key factor in choosing a material?

Not always. The material with the lowest embodied energy might not be very durable; consequently, the life of a product might be short if only embodied energy was used as the criterion. For instance, a spruce lumber deck with low embodied energy might rot out very quickly while a pressure-treated pine lumber deck with higher embodied energy would last much longer. Embodied energy is only one criterion to use when selecting materials.

Is the embodied energy in a structure important compared with the annual operating energy?

A recent study of three actual buildings was done by the Athena Institute (www.athenasmi.ca). The Institute found that the embodied energy in three larger Canadian buildings (the Revenue Canada taxation office in Surrey, B.C.; the Conservation Co-op multi-unit residential building in Ottawa; and the Horton High School in Halifax) ranged between 3.2 and 9 gigajoules/square metre of floor area. Most conventional buildings have an annual energy consumption of approximately 1 gigajoule per square meter per year. The very best larger buildings use about 1/3 that amount.

Using these numbers, the ratio of embodied energy to annual operating energy would likely be in the approximate range of 3 to 27 for common Canadian larger buildings.

What types of buildings have the lowest embodied energy?

For Canadian conditions, wood frame buildings are likely to have much lower embodied energy then steel or concrete buildings, according to a recent study by the Athena Institute for the Canadian Wood Council. The Institute compared the amount of embodied energy in an identical sized building (50,000 square foot [4,620 square metre] floor area three storey office building) designed using three types of construction: wood frame, steel, and concrete. Their finding was that the wood design had the lowest embodied energy of the three structures. The concrete design required 1.5 times as much energy as the wood design and the steel design used 1.9 times the energy of the wood building.

If only the above grade structure was considered (which excludes the concrete underground parking garage), the concrete option required 1.7 times the embodied energy of the wood building and the steel option required 4 times more energy than did the wood option.

Does this mean that wood is the ideal building material?

A canny politician once said: "Don't compare me to some ideal politician; just compare me with the competition." There is no one ideal building material; they all cause some disruption to the earth in their extraction, manufacturing, transportation, assembly and ultimate disposal. For Canadian conditions, however, wood frame does have the edge in terms of lower embodied energy compared with its major competitors.

Letter to the Editor

Re: Predicting Mould Growth in Walls (Solplan Review No. 85 - March 1999)

Your readers may be interested in a little more background behind the article entitled Predicting Mould Growth in Walls. We have seen this work presented before, and have discussed it extensively with NRC staff. The predictive model is based on excellent basic research by VTT Building Technology in Finland. We are concerned, however, that conclusions are being drawn prematurely, without caveats as to its validity and applicability to North American building practice.

One of the most important items to focus on is the caption to Figure 1. This clearly indicates that the predictions were based on a "worst case scenario for exfiltration". If this is not taken into consideration, detectable mould growth resulting from indoor relative humidities less than 35% comes as something of a shock. It should also be noted that these predicted results have not been validated by experiment or by measurements of problem buildings.

What was not mentioned was the fact that these predictions are also based on a worst case scenario for wood surface characteristics. A value of 1, appropriate for surfaced-green lumber, was used in the equation rather than the value of 0, appropriate for surfaced-dry lumber, which predominates in North American construction. Furthermore the coefficients for mould growth were derived from experiments on sapwood of Scots pine, which is highly susceptible to mould, but is not used in North America.

Perhaps the most disturbing implication in this article is that any amount of mould growth constitutes a negative impact on wall performance. Some mould is undoubtedly detectable in any building, with any type of construction. We have been living with moulds for thousands of years. What we need to define is the types and levels of mould growth that have a detrimental impact on the occupants of the building. Only when we know this information, can we confidently predict the performance of wall systems.

We are confident that the author did not intend to imply that all the types of fungi he listed cause significant loss of strength in building envelopes. Nevertheless it should be clarified that this is only true of wood-rotting (basidiomycete) fungi. Mould fungi do not cause loss of strength.

We are working with NRC staff to address these concerns and provide data more appropriate for North American conditions.

Paul Morris
Jennifer O'Connor
Forintek Canada Corp.
Vancouver, BC.

About Your Copy of Solplan Review

We receive many compliments on this publication. You've also often asked us how it is that you receive Solplan Review? We would like to clarify this question, because we rely on subscriptions for revenue. However, the **Canadian Home Builders' Association** has recognized the value of the technical content, and has arranged for all builder members to receive a copy through a bulk subscription. Thus builder members will continue to receive copies if they are members in good standing of the CHBA.

However, because Solplan Review operates on a shoestring budget, we welcome all paid subscriptions (if we do not get enough of them, there will not be enough to cover costs).

We started Solplan Review in 1985 as an independent source to provide information and commentary on all aspects of building science and energy efficient construction for new and retrofit construction. We are still here, primarily because of the support and encouragement we receive from readers (it certainly ain't because of the money!).

If you know colleagues or associates who may enjoy and benefit from a subscription, we hope you will encourage them to subscribe.

Did you know: that more than one third of all bottled water sales in Canada is municipal water that has been filtered? And you thought you were getting spring water from some pristine, remote location in the wilderness!

Have you also noticed that bottled water costs more than gasoline for your vehicle? The cheapest bottled water I have seen in Vancouver area discount supermarkets is about $0.50 per litre, with "premium" water costing more than $1.00 per litre. Compare that with gasoline which sells for around $0.55 - 0.60 per litre (taxes included) in most parts of Canada.

What does that tell us about our priorities? You wonder why we are facing an environmental crisis?

BUILDING BC CODE GUIDE

* Illustrated Reference Guide (1998 BC Building Code)
* Imperial Measurements
* Latest Code Changes
* Model Energy Code Standards

HOUSE CONSTRUCTION IN BC

W.D. Lewicky, P. Eng. • Richard Kadulski, MAIBC

a SOLPLAN REVIEW handbook

A Simplified, Illustrated Guide to Residential Construction in BC

House Construction in BC

by W.D. Lewicky, P. Eng. and Richard Kadulski, MAIBC

The illustrated guide to the 1998 BC Building Code explains Part 9 of the code as it applies to residential construction. This reference guide uses imperial measurements and explains code requirements with sketches where appropriate. The guide highlights the new code changes that came into effect on December 18, 1998.

Editorial comments are made to show where better practice can avoid problems, especially with building envelope detailing.

Also includes highlights of Model National Energy Code for Houses requirements for BC. (These standards are currently optional).

***Only $ 19.95** (+ GST)*

the drawing-room graphic services ltd.
Box 86627 North Vancouver, B.C. V7L 4L2
FAX (604) 689-1841
e-mail: solplan@direct.ca

Is The Earth Flat Too?

The Greening Earth Society (a group linked to the coal industry) says global warming is good, that increases in carbon dioxide (CO_2) levels are beneficial to the environment, and that efforts to reduce greenhouse gas emissions are misguided. The group was formed by the coal industry to provide an alternative voice and to fight the backlash against fossil fuels that is growing because of global warming. It says the earth is getting greener from increased levels of CO_2, and thousands of lives would be saved from warmer winter temperatures.

But have they talked to the low-lying nations and the millions of people who will lose not only their livelihood but also their home when ocean levels rise? Then again, insurance brokers must also be a bunch radicals because they are concerned about weather changes caused by climate change!

What Today's **Best Built Homes** Are Wearing

DOW STYROFOAM CLADMATE Insulated Sheathing

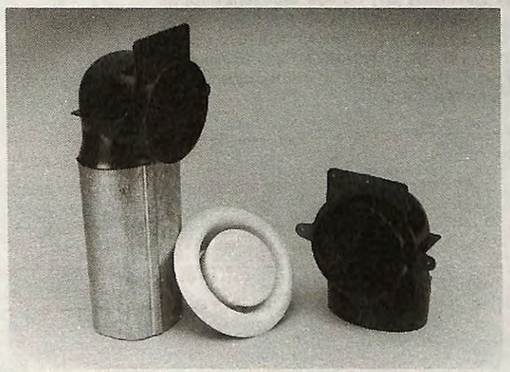
- Prevents heat loss through framing
- Reduces air infiltration
- Cost effective wall insulation
- Easy to work with

For more information visit your local lumberyard or call 1-800-898-WARM (9276)
*Trademark licensed from The Dow Chemical Company

Dave McLung
Construction Materials, Canada, Western Zone
Dow Chemical Canada Inc.
150 - 1657 - 128 St.
Surrey, B.C. V4A 3V2
Tel: (604) 538-5241
Fax: (604) 538-4924

ENEREADY

ENEREADY PRODUCTS LTD. Tel (604) 433-5697 Fax (604) 438-8906
6860 Antrim Avenue, Burnaby, British Columbia, CANADA V5J 4M4



4" albo® - A Fitting Solution for 'whisper' Grill installations

Germans Promote Use of Solar Energy

The German government launched a program to promote the development of solar energy use. Stating this year, 10-year interest-free loans will be available for solar energy installations. The government will also contribute 40 percent of investment costs for solar cells.

The intent is to encourage the use of photovoltaic (solar) cells that generate electricity directly. The generated electricity would provide electricity for the building, and excess would be sold to the electrical grid.

The one-billion mark program (1 Mark is approximately $1.00 Canadian) should lead to a total investment of more than two billion marks. The intent of the program is to offer manufacturers of solar equipment a reliable framework in which to develop products.

Coming Events

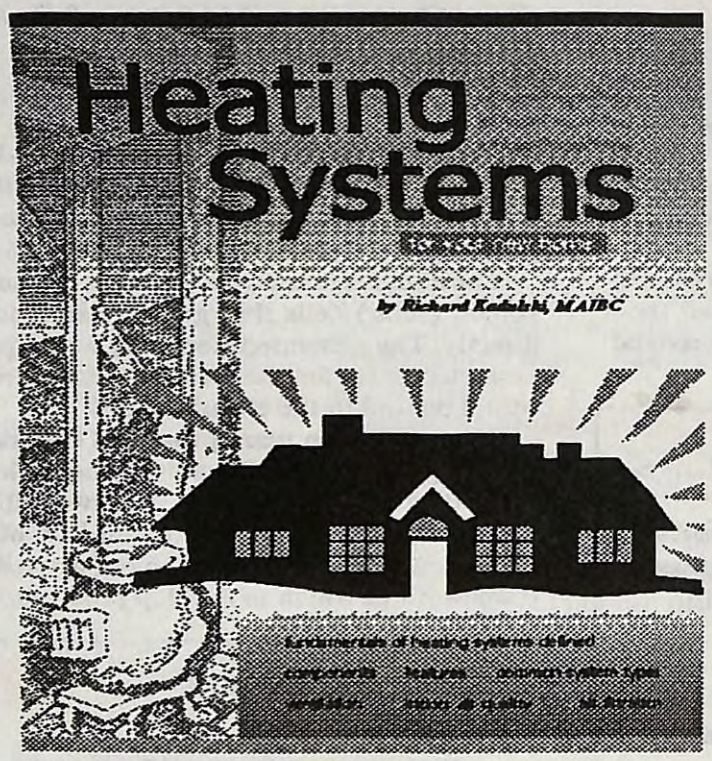
August 11-14, 1999
North Sun '99 (International Conference on solar energy in high latitudes; includes Solar Energy Society of Canada annual conference).
Edmonton, AB.
Tel: 613-234-4151
Fax: 613-234-2988
e-mail: NorthSun@cyberus.ca

Sept 24-25, 1999
CIPHEX '99
(Plumbing & Heating Show)
Toronto, ON
Tel: 416-695-0447
Fax: 416-695-0450
www.ciph.com/ciphex/

Jan 19-20, 2000
Ontario Building & Renovation Forum
Toronto, ON
Tel: 416-447-0077
Fax: 416-443-9982

Jan. 23-23, 2000
Interior Design Show
Toronto, ON
Tel: 416-536-1566
Fax: 416-599-3222
www.interiordesignshow.com

Apr 7-8, 2000
CIPHEX West 2000
(Plumbing & Heating Show)
Calgary, AB
Tel: 416-695-0447
Fax: 416-695-0450
www.ciph.com/ciphex/



Available Now!

Heating Systems
for your new home

by Richard Kadulski, MAIBC

Heating Systems for Your New Home is the book that explains heating system options for your new home.

Contents include:

- **Heating Fundamentals**
- **Heating System Types**
- **Features to consider**
- **Common system types described**
- **Overview of ventilation**
- **Filtration**
- And much more!

$19.95 *Mail order: $ 23.49 ($19.95 + plus $ 2.00 shipping & handling + GST)*

the drawing-room graphic services ltd.
Box 86627 North Vancouver, B.C. V7L 4L2
FAX (604) 689-1841
e-mail: solplan@direct.ca

SOLPLAN REVIEW is an independent Canadian Journal published 6 times per year to serve the needs of professionals and interested lay persons. It provides news, technical details, new product information, insights and commentary on developments covering all aspects of building science and energy efficient building practice for new and retrofit residential construction. Technical information is presented in a clear, concise manner, without resorting to jargon.

SOLPLAN REVIEW is an independent subscription supported publication, that relies on the support of readers. *If you are seeing this journal for the first time, and find it valuable, why not ensure you don't miss any copies. Subscribe today!*

YES, I WANT TO SUBSCRIBE TO **SOLPLAN REVIEW**

In Canada: 1 year: $48.15 ($45.00 + 3.15 GST) [NB, NS, NF $51.75 includes HST]
2 years: 86.67 ($81.00 + 5.67 GST) [NB, NS, NF $93.15 includes HST]

USA and other foreign: 1 year $52.00 per year 2 years: 94.00 (USA and other foreign in US funds)

Pay by: VISA MASTERCARD CHEQUE

Card No. _____ Exp. date: _____

Signature _____

NAME _____

ADDRESS _____

_____

POST CODE _____

the drawing-room graphics services ltd.
Box 86627 North Vancouver, B.C. V7L 4L2
FAX (604) 689-1841
e-mail: solplan@direct.ca